INTERNATIONAL CIVIL AVIATION ORGANIZATION
South American Regional Office - Regional Project RLA/06/901
Assistance for the Implementation of a Regional ATM System, taking into account the ATM operational concept and the corresponding CNS technological support
Tenth Workshop/Meeting of the SAM Implementation Group (SAM/IG/10)
(Lima, Peru, 1-5 October 2012)

SAM/IG/10-WP/15
09/09/12

Agenda Item 8: Other matters

Safety Assessment in RVSM Airspace of CAR/SAM FIRs

(Presented by CARSAMMA)

Summary

This paper presents a summary of large height deviation (LHD) reports received by CARSAMMA and the analysis applying the SMS methodology advocated by ICAO and endorsed by GREPECAS for its application by CARSAMMA in the CAR/SAM Regions.

References

- Annex 11 to the ICAO Convention
- ICAO SMS Manual
- Report of large height deviations (LHDs) in 2011

ICAO Strategic Objectives:	*A – Safety* *B - Security* *C – Environmental protection*

1 Background

1.1. The CAR/SAM Regional Planning and Implementation Group (GREPECAS) entrusted the Caribbean and South American Monitoring Agency (CARSAMMA) the implementation of the SMS methodology for the analysis of LHDs. CARSAMMA is an administrative agency under the *DEPARTAMENTO DE CONTROLE DO ESPAÇO AÉREO* (DECEA), a body that belongs to the Airspace Control System of Brazil (SISCEAB).

1.2. The SMS is used for estimating the risk value of the system.

1.3. An important addition to the methodology for LHD SMS analysis is the risk assessment and quick identification of trends and critical points where risks occur, which reduces the time required to do the safety analysis of the system.

1.4. The objective of this work is to present a summary of the safety assessment in RVSM airspace in CAR/SAM FIRs. The safety assessment was carried out during a 12-month operational period.

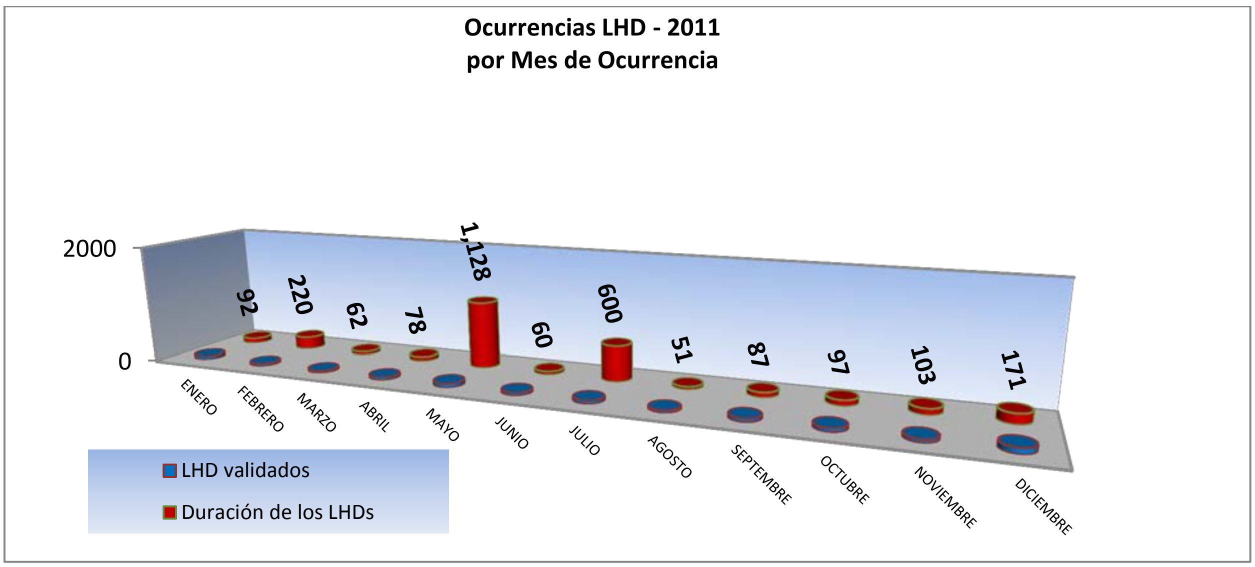
2. Context

2.1. A series of LHD reports accumulated during a period of 12 months (January-December 2011) was used in this safety assessment.

2.2. Table 1 and Figure 1 summarise LHD occurrences validated by the Scrutiny Working Group (GTE) and the duration (in minutes) associated to the LHD per month.

2011					
MONTH	**NUMBER OF LHDs**	**DURATION Total**	**DURATION Average**	**RISK Average**	**Highest RISK**
JANUARY	59	92	1.56	13.92	34
FEBRUARY	42	220	5.24	16.62	40
MARCH	39	62	1.59	15.21	46
APRIL	50	78	1.56	13.42	40
MAY	71	1128	15.89	14.99	37
JUNE	49	60	1.22	11.86	26
JULY	56	600	10.71	14.64	42
AUGUST	40	51	1.28	14.20	34
SEPTEMBER	59	87	1.47	11.08	25
OCTOBER	61	97	1.59	14.69	40
NOVEMBER	54	103	1.91	14.89	40
DECEMBER	91	171	1.88	12.74	25
TOTAL	**671**	**2749**	**4.10**	**14.02**	

Table 1: LHD occurrences, with the duration, average duration, average risk, and highest risk per month



Graph 1: LHD occurrences/duration per month

Graph 1
LHD Occurrences – 2011
by month of occurrence

January, February, March, April, May, June, July, August, September, October, November, December

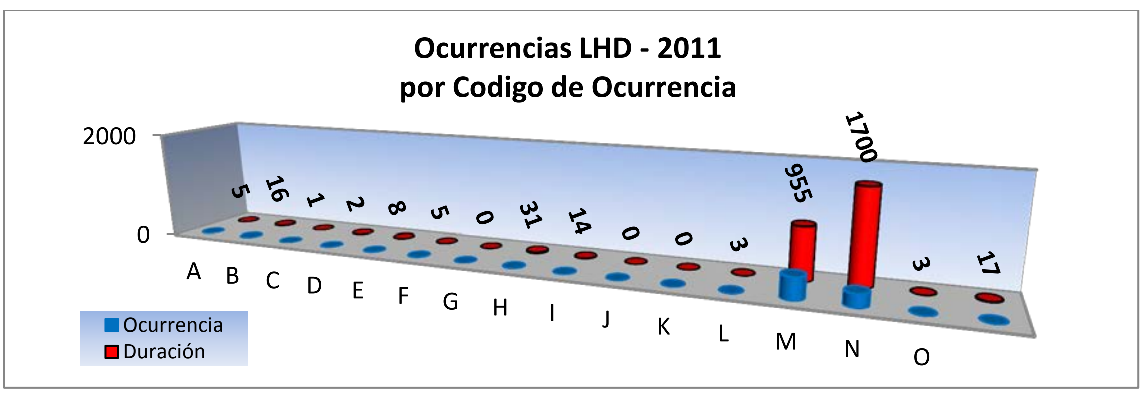
Validated LHDs
Duration of LHDs

2.3. In September, there was a situation in which a single LHD (415) lasted 259 minutes in the Atlántico FIR, and in May, there were several LHDs with a long duration in that same FIR.

2.4. Table 2 and Graph 2 summarise the number of LHD occurrences, the duration (in minutes) associated to the LHD, and the number of flight levels crossed without clearance, by LHD code, from 1 January to 31 December 2011, inclusive.

LHD CODE	Description of LHD Codes	No. of LHD occurrences	Duration of LHD (min)	Levels crossed without clearance
A	Failure to follow climb/descent as cleared	4	5	6
B	Climb/descent without ATC clearance	7	16	7
C	Entry into airspace at incorrect flight level	1	1	1
D	Deviation due to turbulence or other meteorological causes	3	2	2
E	Deviation due to equipment failure	4	8	1
F	Deviation due to collision avoidance system (ACAS / TCAS) warning	8	5	5
G	Deviation due to unexpected event - contingency (engine failure, pressurisation failure)	0	0	0
H	Aircraft not approved for operations in RVSM airspace	5	31	5
I	Misunderstanding by ATC	3	14	6
J	Equipment control error, including incorrect operation of its FMS functions or navigation system	0	0	0
K	Incorrect transcription of ATC clearance or pre-clearance to FMS	0	0	0
L	Incorrect information transcribed to FMS	3	3	4
M	Error in transition message between adjacent ATCs (ATC loop error)	394	955	753
N	Lack of coordination by ATC (lack of coordination)	235	1700	6
O	Other	3	3	6
P	Unknown	1	17	0
Total	(Jan 11 – Dec 11)	671	2756.4	802

Table 2: Summary of LHD occurrences and duration by LHD code



Graph 2: Summary of LHD occurrences, by code

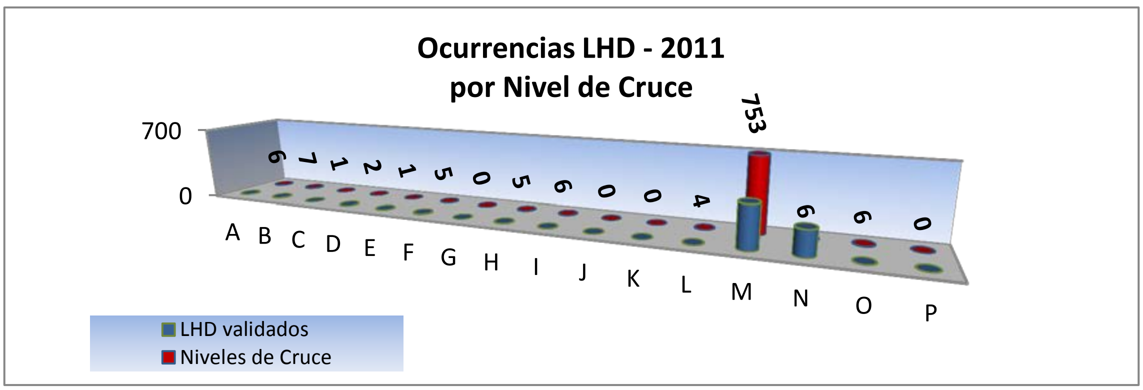
Graph 2
LHD occurrences – 2011
by occurrence code

Occurrence
Duration

2.5. M-coded LHDs (error in ATC transition messages) were the most frequent in 2011, totalling 394 events, followed by codes N (235), F (8), and B (7). The large number of these (M-coded) LHDs reveals the need for better coordination between adjacent air traffic control units, which could be achieved by sensitising and training controllers in the area of coordination.

2.6. Likewise, Graph 2 shows that N-coded LHDs were the most significant in terms of duration, with a total duration of 1,700 minutes. This is one of the worst air traffic incidents, since the aircraft involved were not expected to be in that position or at that level or at the time of occurrence.

2.7. Graph 3 shows LHDs in which levels were crossed without ATC clearance. In this case, M-coded levels were the most significant, totalling 753 crossings. Likewise, in the case of N-coded LHDs, the controller ignores the traffic and the level is cleared by the adjacent sector.

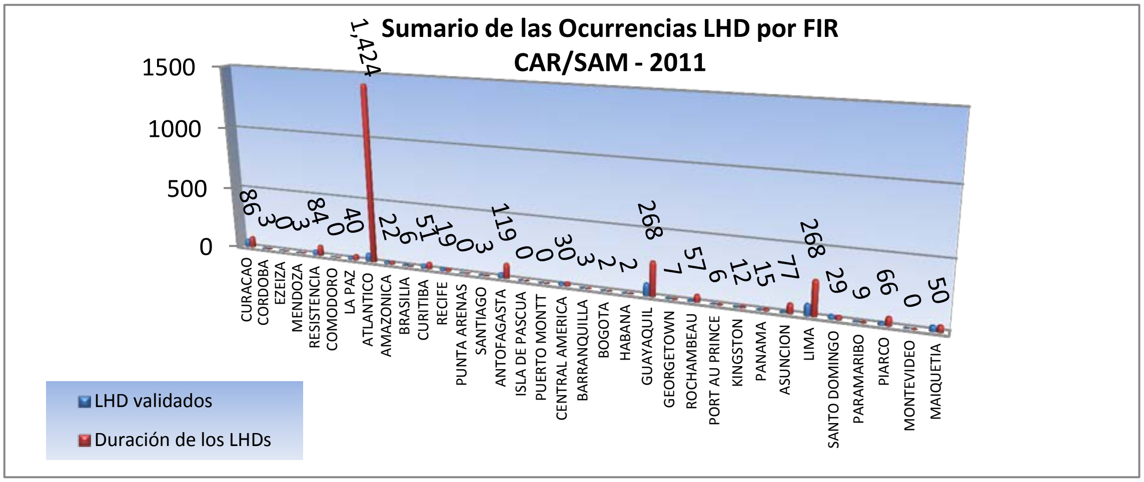


Graph 3: Summary of LHD occurrences by level crossed

Graph 3
LHD Occurrences – 2011
by level crossed

Validated LHDs
Levels crossed

2.8. Graph 4 shows all validated LHDs, by FIR. It should be noted that the Atlántico FIR has the highest absolute duration in minutes; accordingly, aircraft using that FIR are more exposed to operational risk



Graph 4: Summary of LHD occurrences by FIR

Graph 4
Summary of LHD occurrences, by FIR
CAR/SAM – 2011

Validated LHDs
Duration of LHDs

3. Risk value (VR) assessment

3.1. This section updates the results of the RVSM airspace safety assessment in CAR/SAM FIRs. The risk value assessment (SMS) methodology was used for conducting the internationally accepted safety assessment of this airspace.

3.2. VR parameter estimates – The values of the internationally accepted risk value (VR) parameters used for the RVSM airspace safety assessment are summarised in the following formula and described in Table 3.

VR=(PxDxS)+R+W+T, where:

Parameter	Description	Value
VR	Risk value	**To be calculated**
P	Probability of the position	**Varies from 1 to 5**
D	Duration of the event	**Varies from 1 to 3**
S	Severity of the event	**Varies from 1 to 5**
R	With or without RADAR/ADS	**With=0 or without=5**
W	Weather conditions	**VMC=0 or IMC=5 if there is another aircraft**
T	Other traffic (if any)	**Ranges from 1 to 15 (of separation)**
	TOTAL	**Maximum 100**

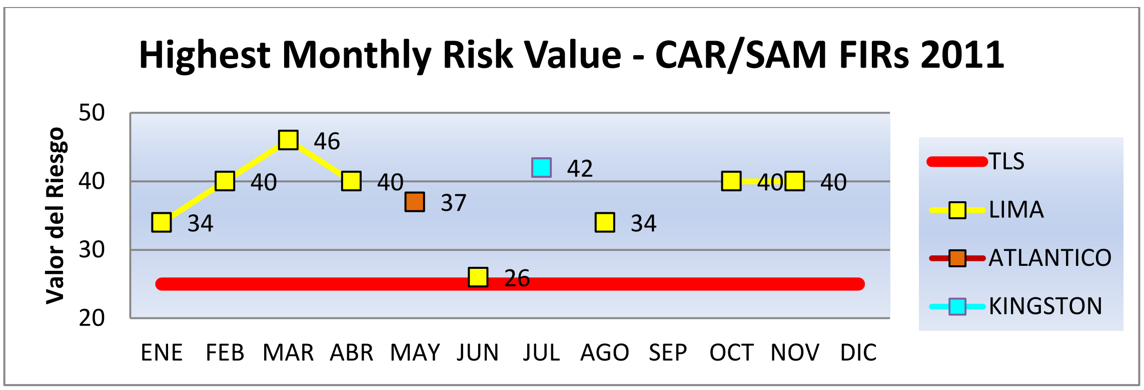
Table 3: Calculation of risk value parameters

3.3. Safety assessment – The results of the CAR/SAM FIR airspace safety assessment are shown in Table 4 and Graph 5 (FIRs with LHDs with VR greater than 25).

	TLS	LIMA	ATLANTIC	KINGSTON
JAN	25	34		
FEB	25	40		
MAR	25	46		
APR	25	40		
MAY	25		37	
JUN	25	26		
JUL	25			42
AUG	25	34		
SEP	25			
OCT	25	40		
NOV	25	40		
DEC	25			

Table 4: Estimates of the greatest LHD risk value

3.4. Graph 5 shows the highest risk value estimates produced every month based on LHD reports from 1 January to 31 December 2011.



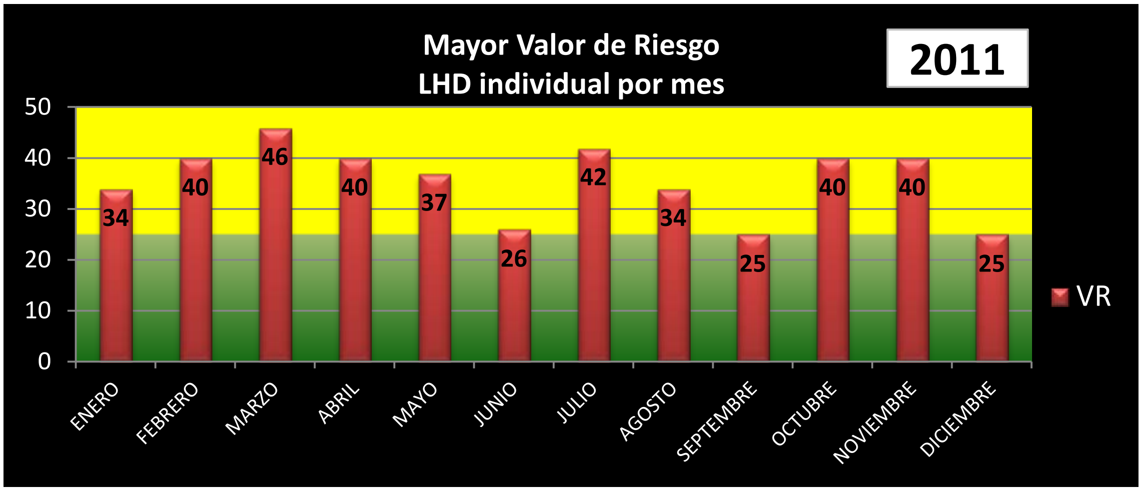
Graph 5: Highest risk value for FIRs in CAR/SAM RVSM airspace. The red line represents the VR of the TLS (25).

Graph 5
Risk value
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

3.5. In 2011, the safety risk value for the Lima FIR was eight times greater than the Target Level of Safety (TLS – red line in Graph 5), that is, more than 25 points. The Atlántico and Kingston FIRs have a VR that exceeds the TLS during two of those months. The TLS was established at the 11th meeting of the Scrutiny Working Group (ICAO GTE/11) held in 2011 (Lima, Peru).

3.6. CARSAMMA has assessed LHD occurrences (specific operational error) in CAR/SAM RVSM airspace from the point of view of the contribution of the individual LHD occurrence to the total risk in the FIR. Furthermore, the risk value was determined on a monthly basis in an attempt to provide risk information in real time.

3.7. Graph 6 shows LHDs with the highest individual VRs in 2011.



Graph 6: Highest individual LHD risk value in 2011, by month

Graph 6

Highest Risk Value
Individual LHD, by month

January February March April May June July August September October November December

4. LHD safety assessment (SMS)

4.1. Table 5 lists the LHDs or operational errors assessed by the GTE as having the highest risk value (> 25) in 2011.

4.2. LHD 171, occurred in March 2011, accounted for 12.89% of the risk assessment for that month, and has a VR = 46, the highest in the sample.

4.3. The Lima FIR appears 20 times with LHD reports from adjacent FIRs, since it contributed to the generation of risk in their RVSM airspace.

4.4. In turn, the Guayaquil FIR appears 14 times as risk generator.

Sequence	FIR subject to the risk	Risk generation	GTE code	Risk value
171	**LIMA**	**BOGOTA**	**N**	**46**
383	KINGSTON	PILOT	**I**	42
117	LIMA	GUAYAQUIL	**N**	40
159	LIMA	ANTOFAGASTA	**N**	40
220	LIMA	GUAYAQUIL	**N**	40
573	LIMA	GUAYAQUIL	**N**	40
691	LIMA	GUAYAQUIL	**N**	40
126	LIMA	GUAYAQUIL	**N**	37
316	ATLANTICO	MONTEVIDEO	**N**	37
415	ATLANTICO	MONTEVIDEO	**N**	37
44	LIMA	GUAYAQUIL	**N**	34
218	GUAYAQUIL	BOGOTA	**M**	34
274	PIARCO	MAIQUETIA	**N**	34
447	LIMA	GUAYAQUIL	**N**	34
636	LIMA	GUAYAQUIL	**N**	34
268	LIMA	ANTOFAGASTA	**M**	30
465	LIMA	LIMA	**M**	30
587	ANTOFAGASTA	LIMA	**M**	30
629	LIMA	GUAYAQUIL	**M**	30
652	GUAYAQUIL	LIMA	**C**	30
677	LIMA	ANTOFAGASTA	**M**	30
257	ROCHAMBEAU	DAKAR	**N**	28
266	ATLANTICO	MONTEVIDEO	**N**	28
438	LIMA	GUAYAQUIL	**M**	28
438_1	GUAYAQUIL	CENTRAL AMERICA	**M**	28
452	LIMA	AMAZONICA	**N**	28
105	RESISTENCIA	CURITIBA	**N**	27
382	ATLANTICO	PILOT	**B**	27
102	PIARCO	MAIQUETIA	**N**	26
292	LIMA	GUAYAQUIL	**M**	26
320	LIMA	GUAYAQUIL	**M**	26
345	LIMA	GUAYAQUIL	**M**	26
615	LIMA	GUAYAQUIL	**M**	26

Table 5: LHDs assessed as having the highest risk value in 2011.

4.5. The analysis process includes a detailed revision of certain operational errors with a view to identifying the contributing factors and making sure that the safety authorities of the CAR/SAM FIRs implement procedures and processes to reduce the probability of recurrence of the same errors.

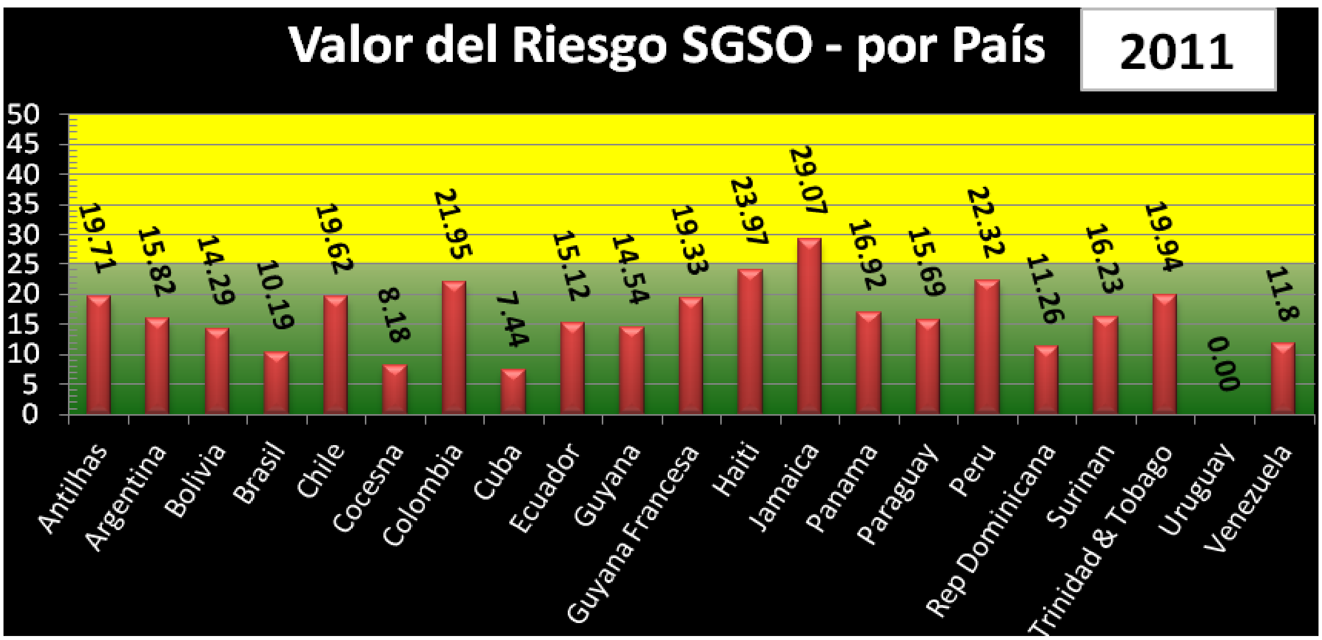
In the case of RVSM airspace, CARSAMMA assessed the individual operational errors identified in the LHD reports submitted by the 34 FIRs within its geographical coverage, grouped by FIR and then by State, using the following statistical tools:

Risk value **mean** ⇒ $M = \sum VR \; / \; n$;

Standard deviations ⇒ $$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x-\bar{x})^2}$$ and

Confidence interval for the 95% analysis (= 1,96).

4.6. Graph 8 shows the results of this analysis with the contribution of LHD operational errors to the risk value, as assigned by the State in the analysis of 2011 data.

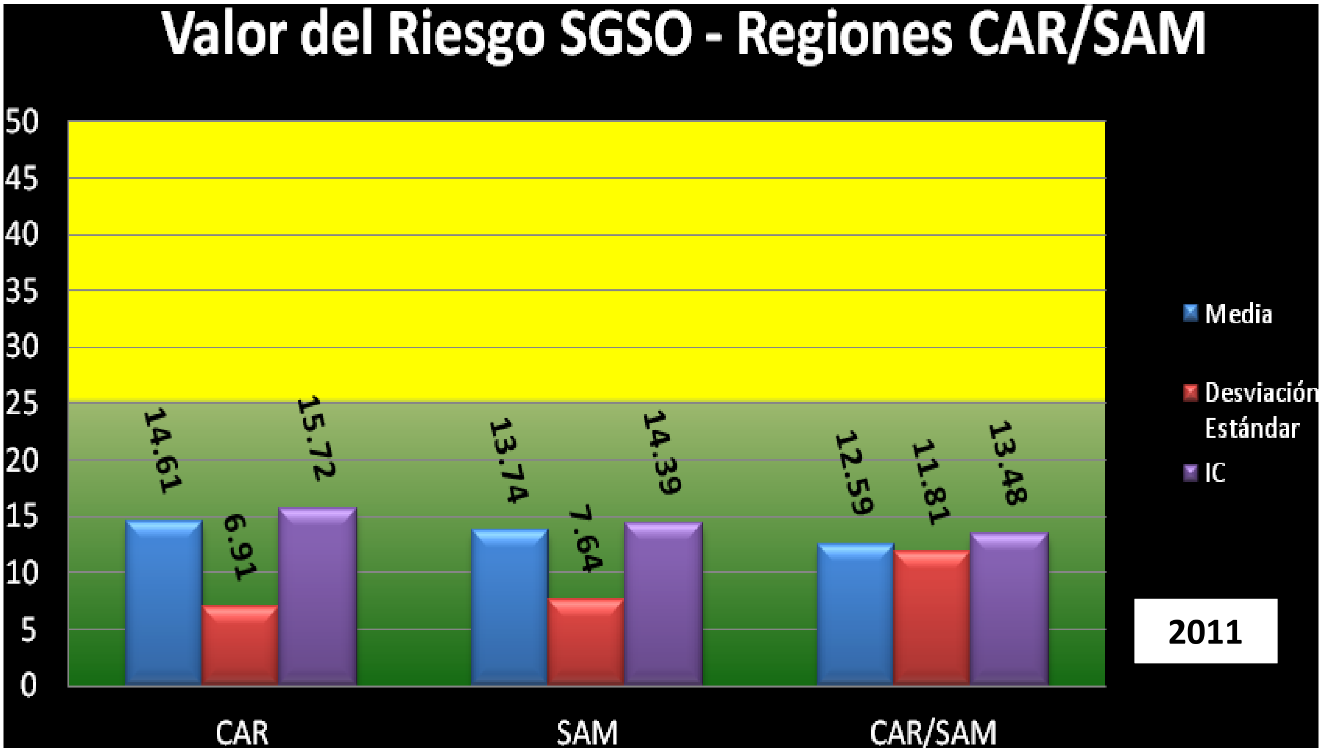


Graph 8: Contribution of risk value, by State

Graph 8
SMS Risk Value – by country

Brazil
French Guiana
Dominican Republic
Suriname

4.7. Graph 9 shows the result of the analysis conducted in the CAR Region and in the SAM Region and in the CAR/SAM Regions as a whole. Note that the M-coded LHDs are the most significant with a rate of 58% (394 LHDs) of total LHDs, followed by N-coded LHDs with 35% (235 LHDs).



Graph 9: Contribution of CAR, SAM and CAR/SAM Regions to the risk value

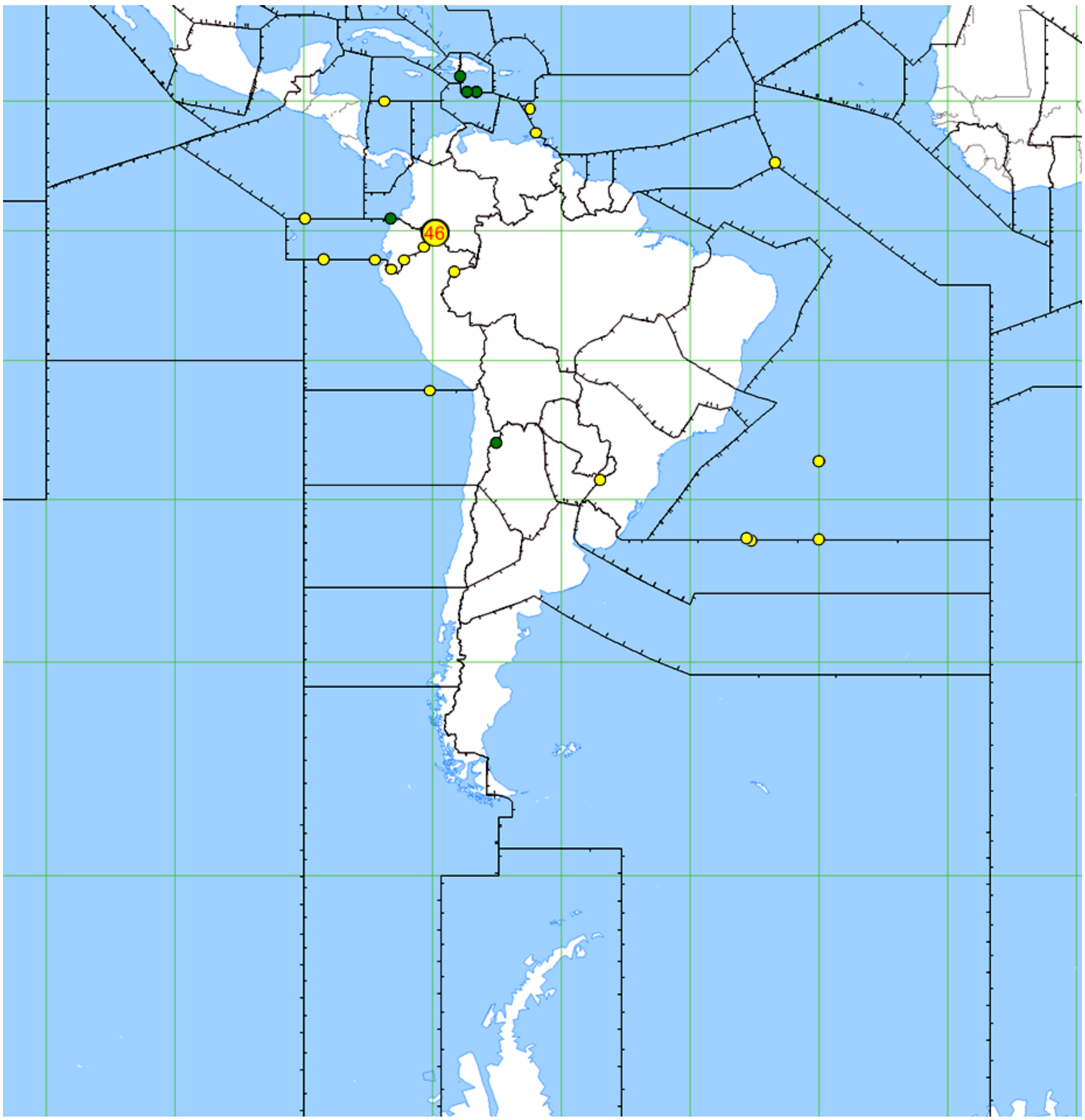
Graph 9

SMS Risk Value – CAR//SAM Regions

Mean
Standard deviation

4.8. Graph 10 illustrates the geographic location of risk points (hot spots) that have 25 points or more in the data set for 12 consecutive months in the LHD reports issued by CAR/SAM FIRs. Each LHD is identified as a colour dot. LHDs considered to be of medium risk (26 or more) are shown in yellow, and low risk LHDs in green. The image seeks to provide a way of identifying specific risk points related to RVSM operations.

4.9. The Lima FIR boundaries continue to show a high number of LHDs, mostly N-coded errors (lack of coordination). Likewise, there are several LHDs identified in the data set in the vicinity of the Guayaquil FIR.



Graph 10: CAR/SAM FIRs - RVSM risk points of Large Height Deviation (LHD) Risk Points
January – December 2011

5. Suggested action

5.1. The Meeting is invited to:

a) Take note of the information provided herein, which may be used by the States as a reference for mitigating their LHDs; and

b) Advise the SAM/IG/10 Meeting of such decision for its knowledge and approval.

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